Appendix I
LAKE ISTOKPOGA SURFACE WATER MANAGEMENT ASSESSMENT

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LAKE ISTOKPOGA-INDIAN PRAIRIE BASIN WATER AVAILABILITY AND SUPPLY FOR 2020 DEMAND CONDITIONS

Introduction

This report was prepared in support of the Kissimmee Basin (KB) Water Supply Planning effort. The described analysis evaluates the availability of local sources in the Lake Istokpoga-Indian Prairie Basin to meet the 2020 projected demand conditions during a 1-in-10 year drought. The projected water supply demands from 1995 to 2020 are found to be met through the combined use of unused storage in Lake Istokpoga above its current minimum operation schedule and through the use of Lake Okeechobee employing pump stations G-207 and G-208. Figures cited in this report begin on page I-13.

Rainfall Data

An analysis of 26 years of data for the period of 1972 to 1997 for the Lake Istokpoga-Indian Prairie Basin indicated that an estimate of a 1-in-10 year drought event would total 36.19 inches annually. This rainfall is not distributed evenly throughout the year. As part of the rainfall analysis, the seasonal variation was also estimated. Three years from 1972 to 1997 were found (1981, 1985, and 1996) to have approximately 1:10 year drought rainfall amounts during dry and wet seasons as shown in **Table I-1**. Estimates of the seasonal nature of a 1-in-10 year drought include 11.14 inches during the dry season (November through May) and 21.68 inches during the wet season (June through October). Further details of this rainfall analysis are located at the end of this report.

Table I-1. Representative Years of 1-in-10 Year Drought Conditions for Seasonal Rainfall.

Season	Rainfall (in)			
	1-in-10 (Drought)	1981	1985	1996
Dry	11.14	9.31	11.18	14.66
Wet	21.68	23.72	25.50	21.34
MSE (in^2)	---	13.64	12.46	9.62

Mean Square Error (MSE) analysis showed that the closest rainfall distribution month by month of the 1-in-10 year drought conditions occurred in 1996 (MSE = 9.62 in^2). Since October is the last month of the wet season, its average stage was taken as initial condition for the selected years.

Lake Istokpoga Stage Data

Monthly stages for Lake Istokpoga for the period of 1972 through 1997 are shown in **Figure I-1**. **Figure I-2** shows the current regulation schedule and minimum operating level for the lake. Stage-Duration curves for Lake Istokpoga preregulation (October 1983 through March 1990) and for current regulation (April 1990 through December 1997) are shown in **Figures I-3** and **I-4**. Comparison of **Figures I-3** and **I-4** indicate that higher stages in the lake occur after the current regulation schedule was implemented in 1990.

Table I-2 shows the effect of dry conditions for 1996. The mean stage for October of the previous year (1995) is considerably higher than 1996 (almost 0.9 feet).

Table I-2. Lake Istokpoga Stage for Month of October for the Selected and Previous Years.

Mean Stages (ft NGVD)						1972-1997		
1980	**1981**	**1984**	**1985**	**1995**	**1996**	**Maximum**	**Mean**	**Minimum**
38.19	39.06	38.42	39.52	39.36	38.48	39.52	39.13	38.17

Table I-3 provides a summary of the monthly average water elevations for Lake Istokpoga during the period of the pre-1990 regulation schedule (1972-1990) and the post-1990 regulation schedule (1990-1997). The column under Line A is the elevations for flood control releases while Line B represents the current minimum operational level for the lake.

Table I-3. Summary of Monthly Average Water Elevations for Lake Istokpoga.

Month	1972-1990 Ave. Stage	1990-1997 Ave. Stage	Line A Regulation Schedule (NGVD)	Line B Regulation Schedule (NGVD)
January	39.10	39.12	39.50	38.50
February	39.08	39.11	39.50	38.37
March	38.88	39.12	39.50	38.25
April	38.34	38.96	39.50	37.75
May	37.65	38.50	39.50	37.50
June	37.45	38.35	38.75	37.50
July	37.80	38.40	38.25	37.50
August	38.21	38.55	38.25	38.00
September	38.72	38.87	38.25	38.25
October	39.07	39.28	38.50	39.00
November	39.04	39.28	39.50	38.75
December	39.05	39.16	39.50	38.50

Water Availability for 2020 Conditions

Water availability for 2020 demands and 1:10 year drought conditions were analyzed. This analysis considers two possible sources to meet the projected surface water demands. The first source is the storage in Lake Istokpoga above the current minimum operation levels as shown in column 3 of **Table I-5**. The other possible source is backpumping from Lake Okeechobee using pumping stations G-207 located on the C-41 Canal and G-208 located on the C-40 Canal. These pumps are located adjacent to structures S-71 and S-72 respectively. Each pump has a rated capacity of 60,000 GPM.

Water moved from Lake Okeechobee into the basin was not moved above structures S-70 and S-75. **Figure I-5** shows the locations of the structures and canals in this basin. Currently, pump G-207 can supply the C-41 Basin between structures S-71 and S-70, and pump G-208 can supply the C-40 basin between structures S-72 and S-75 .

The first analysis was initiated with a stage for October equal to the average stage for the months of October between 1972 and 1997 (i.e., 39.13 ft NGVD) as depicted in **Table I-5**. A detailed description of the computations is given in **Table I-4**.

An additional component of the water budget within Lake Istokpoga is its change in storage. The change in storage represents the balance of inflows and outflows coming in and leaving the lake and other components such as rainfall, evapotranspiration, seepage, aquifer recharge, etc. A general indication on how all the components affect the Lake Istokpoga storage can be evaluated by using mean stages of the lake. In this case, monthly time steps are utilized for that purpose for the three years with similar rainfall to 1:10 year dry conditions (i.e., 1981, 1985, and 1996). **Table I-3** shows the monthly estimates of the change in storage component for the three considered years for Lake Istokpoga. The average monthly values for 1981, 1985, and 1996, represent the amount of water gained (positive, inflows larger than outflows) or lost (negative, outflows larger than inflows). This factor was estimated by determining the difference in monthly mean lake stage and removing the amount of water released through S-68. The gain/loss is used to balance the stages in the lake every month after the deficit has been supplied from Lake Istokpoga and/or G-207 and G-208 pumping stations. A gain (positive value) will increase the stage in the lake for the following month in that value. On the contrary, a loss (negative value) will decrease the stage in the lake for the following month in that value.

Table I-4. Description of Computations (for Table I-4).

[1] Calculations begin in October, the last month of the wet season, where the lake has recovered and most likely will reach high stage.

[2] These values represent the increase in monthly 2020 demand amounts under 1-in-10 drought conditions that remain after existing discharges from Lake Istokpoga and Indian Prairie Basin (also under 1-in-10) were assumed to be used to meet a portion of the total demand. The estimates were based upon water use estimates determined as part of the KB Water Supply Plan effort.

[3] Average monthly stages of the current regulation schedule of Lake Istokpoga (line between zones B and C of Figure 2).

[4] Stages at the end of the month (EOM). The initial stage is the stage in the lake assumed for the initial month (October). The deficit that could be supplied by the lake is estimated month by month without exceeding the minimum regulation schedule (column [3]).

[5] Percents of the deficit that could be supplied by the additional storage in the lake without exceeding the minimum regulation.

[6] Change in storage in the lake such as ET loss, unknown discharges, seepage, rainfall and inflows into the lake.

[7] Volumes (capacities in the lake) at the end of the month after supplying the optimum percent of the deficit. The initial volume corresponds to the capacity in the lake for the initial stage for the month of October. These volumes are estimated from the Stage-Capacity **(Figure I-6**) equation developed for Lake Istokpoga once the EOM stage is computed.

[8] Stages EOM - Minimum Regulation ([4]-[3]).

a) If this value is positive, 100% of the deficit can be supplied by the additional storage in the lake without exceeding the minimum regulation.

b) If this value is zero, less than 100% of the deficit can be supplied by the additional storage in the lake without exceeding the minimum regulation. The difference in deficit could be supplied by an additional source (Pumps G-207 and G-208, in this case [10]).

c) If this value is negative, the lake can not supply the deficit, unless that surplus is available (e.g., deficit is negative as in August). Note that in this case the additional water (surplus) will replenish the capacity in the lake for the next month (e.g., September) increasing the capacity of August with respect to July in that surplus amount (e.g., 8,300 acre-ft).

[9] Deficit supplied by additional storage in Lake Istokpoga without exceeding the minimum regulation schedule.

[10] Remaining deficit supplied by Pumps G-207 and G-208.

[11] Number of days per month of G-207 and G-208 operation based on 270 cfs combined capacity and 24 hours of operation per day.

Table I-5. Water Deficit for 2020 Conditions (1-in-10 Dry) Supplied by Available Storage in Lake Istokpoga and G-207 and G-208 Pump Stations (from Lake Okeechobee). Initial stage = Average Oct. (72-97).

[1] Month	[2] Deficit (acre-ft)	[3] Min. Stg. Reg. Sch. (ft NGVD)	[4] Stage EOM (ft NGVD)	[5] % Def from LI	[6] Gain/Loss of Storage (ft)	[7] Vol LI EOM (acre-ft)	[8] Stg EOM Reg. Sch. (ft)	Supply (acre-ft)		[11] # Days per Month
								[9] from LI	[10] G207_8	
Initial Stage			39.13				Initial Volume			
October	-274	38.83	39.50	100	0.39	178,530	0.7	0	0	0
November	5,174	38.75	39.50	20	0.03	188,787	0.77	1,033	4,131	7.7
December	4,148	38.54	39.33	50	-0.12	187,582	0.79	2,074	2,074	3.9
January	6,630	38.45	39.22	33	-0.04	181,920	0.77	2,188	4,442	8.3
February	7,878	38.35	39.14	22	-0.02	179,092	0.79	1,733	6,145	11.5
March	12,353	38.18	38.92	22	-0.12	175,732	0.74	2,718	9,635	18.0
April	9,547	37.75	38.63	24	-0.21	169,967	0.88	2,291	7,256	13.5
May	7,759	37.50	38.04	22	-0.53	162,181	0.54	1,707	6,052	11.3
June	6,128	37.50	37.87	13	-0.15	146,040	0.37	797	5,331	9.9
July	1,364	37.67	38.12	40	0.38	141,152	0.45	546	818	1.5
August	-8300	38.03	38.60	100	0.27	151,769	0.57	0	0	0
September	3,966	38.46	39.04	50	0.51	160,787	0.58	1,983	1983 ,	3.7

Figures

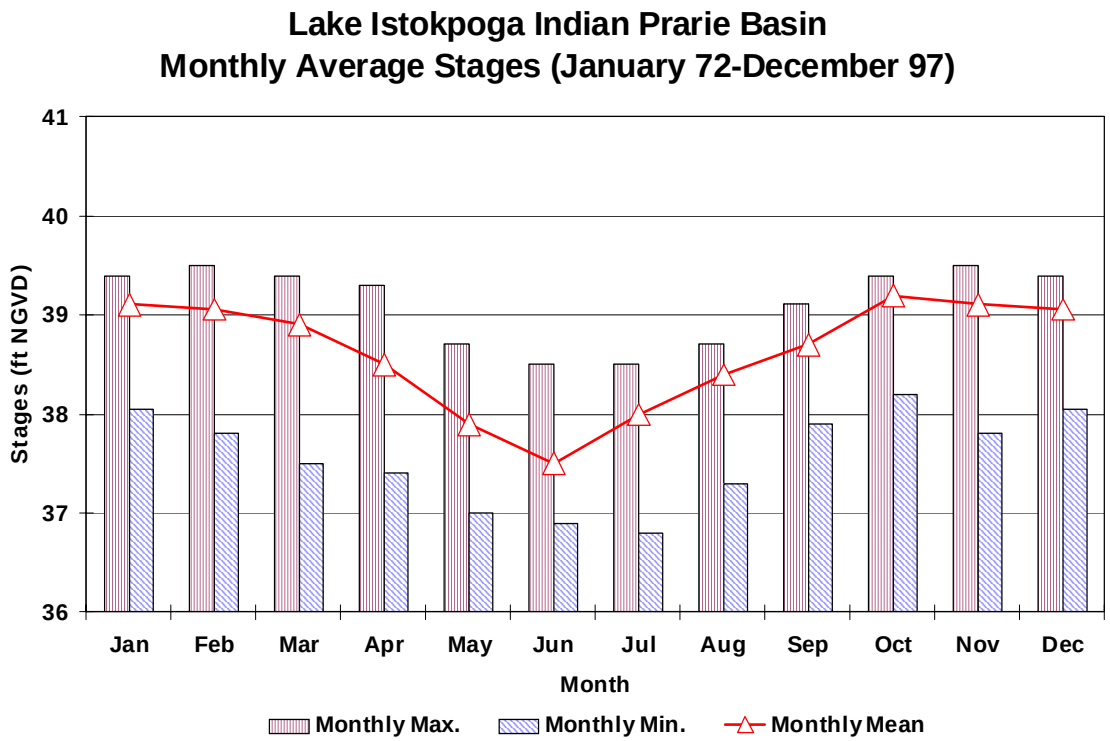

Figure I-1. Monthly Stages for Lake Istokpoga for the Period of 1972 through 1997.

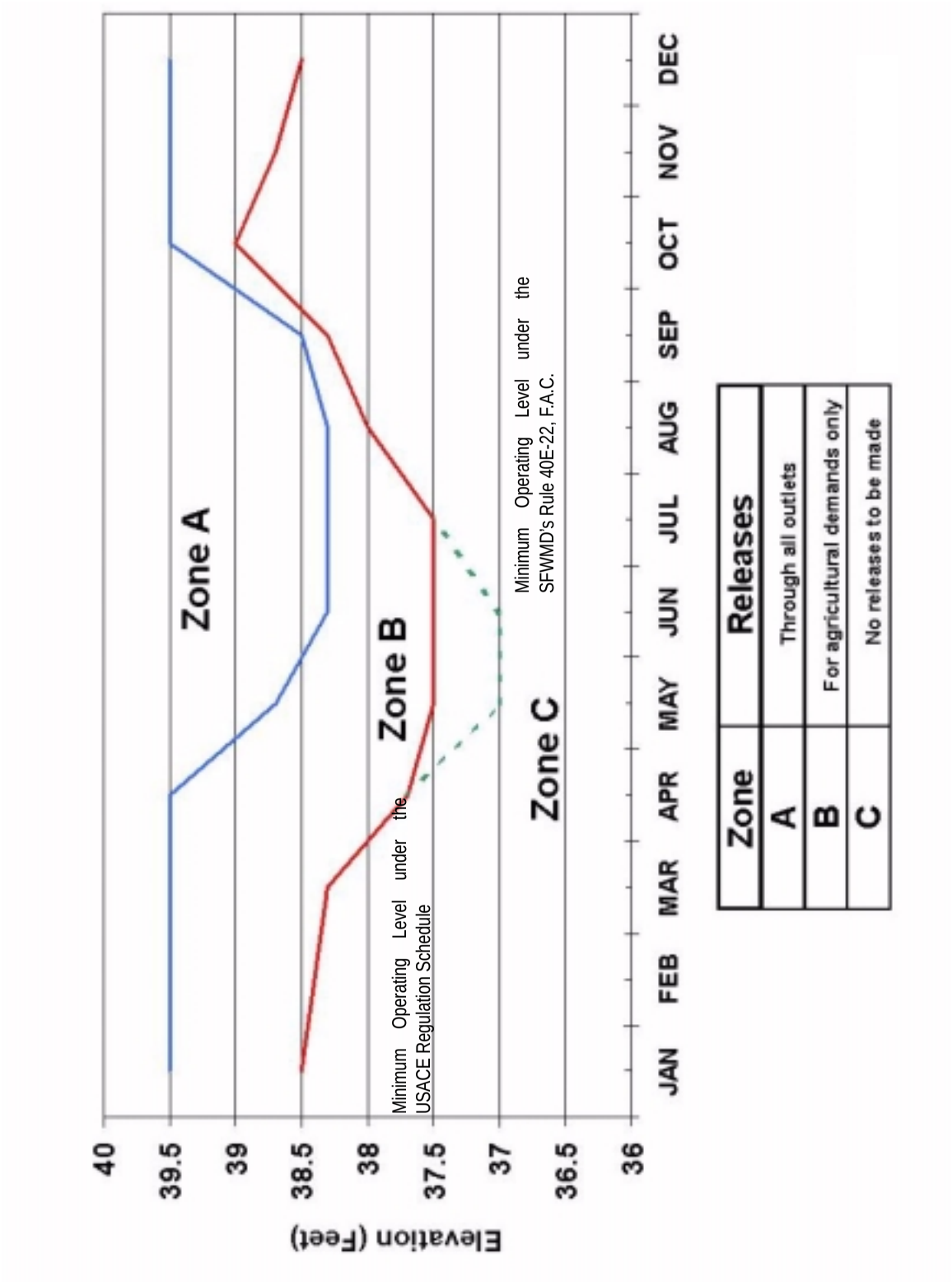

Figure I-2. Current Regulation Schedule and Minimum Operating Level for Lake Istokpoga.

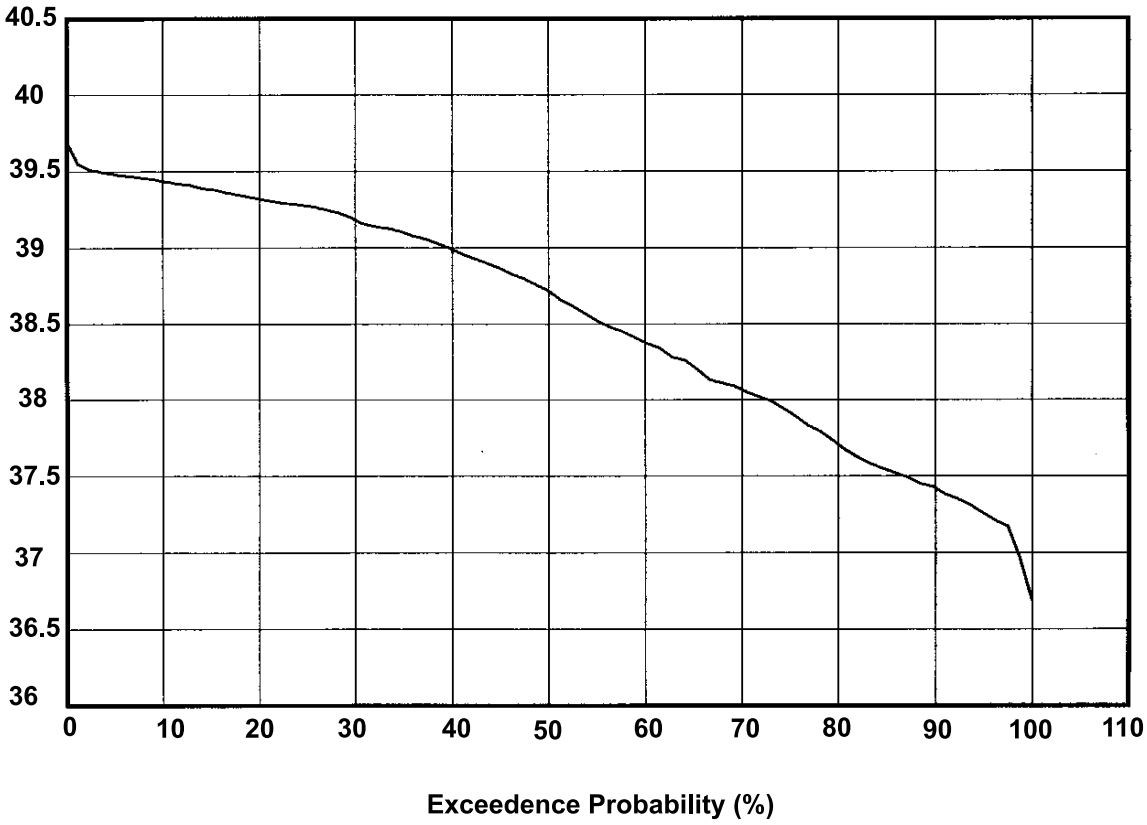

Figure I-3. Stage-Duration Curve for Lake Istokpoga (prior to current regulation schedule, October 1983 through March 1990).

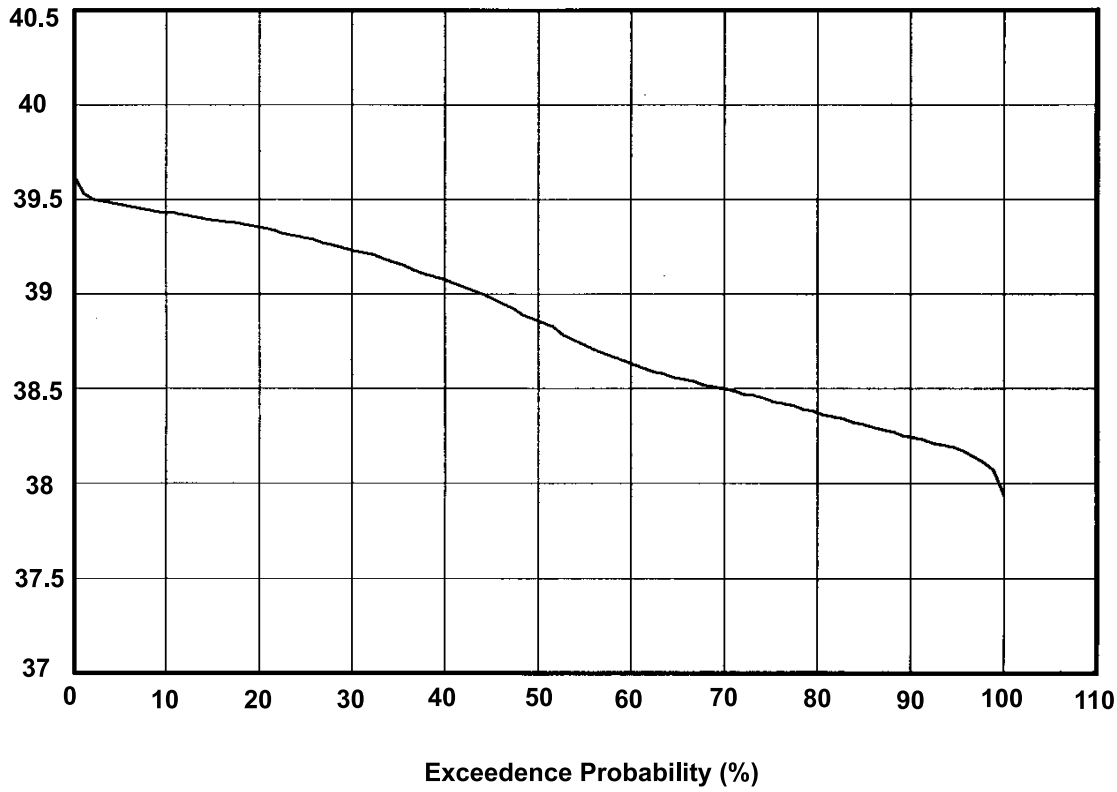

Figure I-4. Stage-Duration Curve for Lake Istokpoga (current regulation schedule, April 1990 through December 1997).

Figure I-5
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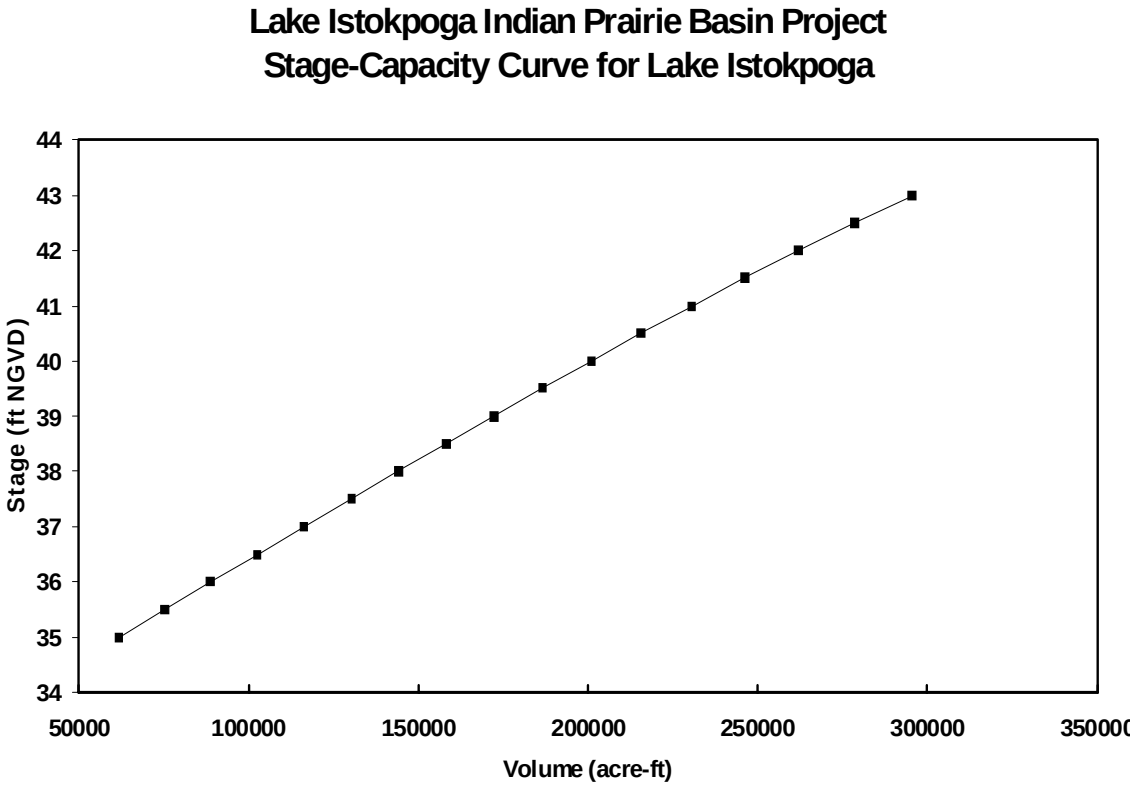

Figure I-6. Stage-Capacity Equation Developed for Lake Istokpoga.

LAKE ISTOKPOGA-INDIAN PRAIRIE BASIN RAINFALL ANALYSIS

Estimates of the 1-in-10-year dry and wet conditions (drought and flood, respectively) as well as 1-in-2-year average rainfall per season and per calendar annual year were obtained. Monthly values from 1977 to 1997 were used with the wet season consisting of the months of June through October, and dry season of November through May. Histograms for the selected 21 years are shown in **Figure I-7** for wet and dry seasons and calendar annual year. From the three histograms the probability density function (PDF) and subsequently the cumulative distribution function (CDF) for each of the three conditions were obtained (**Figures I-8** through **I-13**). The final results are included in **Table I-6.**

Table I-6. Lake Istokpoga-Indian Prairie Basin Rainfall Magnitude and Frequency.

Rainfall Period	Weather Conditions		Return Period (years)
	Dry (Drought) (in)	Wet (Flood) (in)	
Wet Season	27.12 21.68	27.12 32.56	2 10
Dry Season	16.64 11.14	16.64 22.17	2 10
Calendar Annual Year	44.24 36.19	44.24 53.30	2 10

By normalizing the monthly values of the 21-year period of time, the normal rainfall was obtained. The normal rainfall has to be very similar to the 1-in-2 return period rainfall for which the dry and wet conditions coincide. The results are shown in **Table I-7**. The seasonal and total annual rainfall amounts from **Table I-6** coincide well with the obtained amounts from the previous analysis (**Table I-5**). The monthly amounts for dry and wet season (**Table I-6**) were used to estimate the percentages and monthly rainfall distributions for the 1-in-2, 1-in-10 dry (drought) and wet (flood) conditions as shown in **Table I-8**. **Figure I-14** depicts the monthly amounts for the 1-in-10 year rainfall for both dry and wet conditions.

Table I-7. Lake Istokpoga-Indian Prairie Basin Normal Monthly Rainfall Analysis.

Month	Mean Intercept (in)	Standard Deviation Slope (in)	Skewness
January	1.95	1.57	1.52
February	2.25	1.87	2.19
March	2.92	1.53	0.49
April	2.44	1.59	0.15
May	3.78	1.72	0.33
June	6.62	2.54	0.45
July	6.66	2.26	1.15
August	6.15	2.12	0.08
September	5.47	2.78	1.31
October	2.71	2.17	1.76
November	2.00	1.71	1.64
December	1.78	1.60	0.96
Total Annual	44.72		
Total Dry Season	17.11		
Total Wet Season	27.61		

Table I-8. Monthly Rainfall Amounts for 1-in-2, 1-in-10 Dry, and 1-in-10 Wet Return Periods.

Month	Percent Rainfall		Monthly Rainfall (in)		
	Dry Season	Wet Season	1-in-10 Dry (Drought)	1-in-2	1-in-10 Wet (Flood)
January	11.41		1.27	1.90	2.53
February	13.16		1.47	2.19	2.92
March	17.05		1.90	2.84	3.78
April	14.24		1.59	2.37	3.16
May	22.08		2.46	3.67	4.90
June		23.99	5.20	6.51	7.81
July		24.12	5.23	6.54	7.85
August		22.27	4.83	6.04	7.25
September		19.80	4.29	5.37	6.45
October		9.82	2.13	2.66	3.20
November	11.69		1.30	1.94	2.59
December	10.38		1.16	1.73	2.30
Total	100.00	100.00	32.82	43.76	54.73
Dry Season	*These amounts from Table I-1*		11.14	16.64	22.17
Wet Season			21.68	27.12	32.56

Figures

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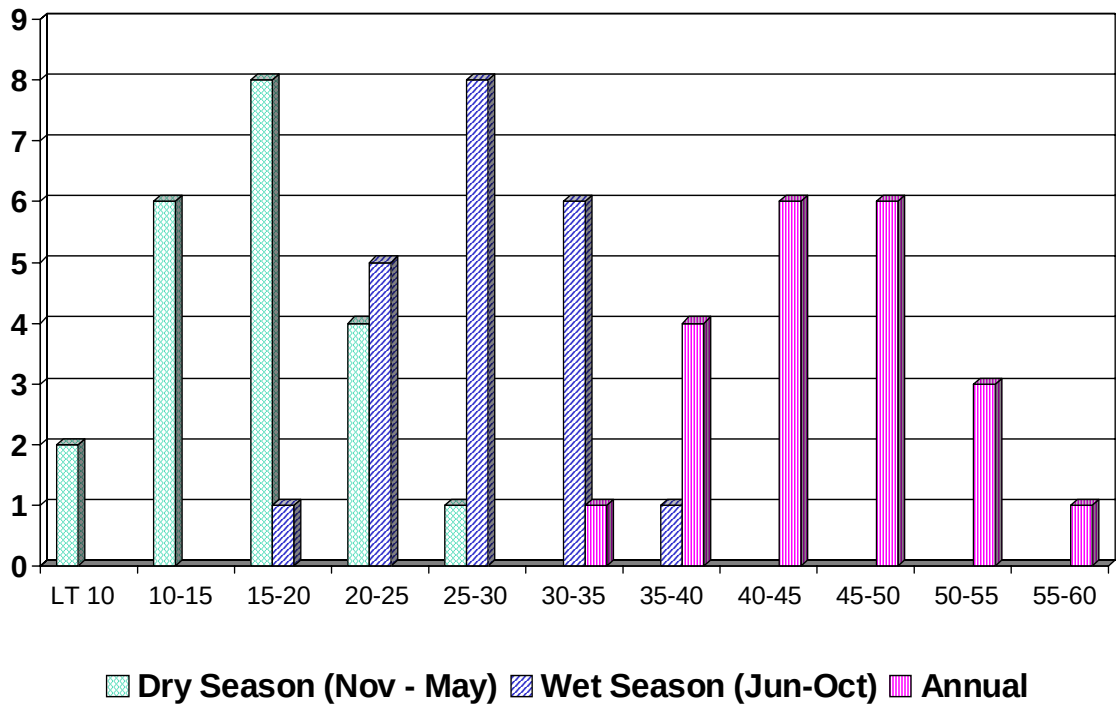

Figure I-7. Monthly Rainfall Amounts for the 1-in-10 Year Rainfall (Dry and Wet Conditions).

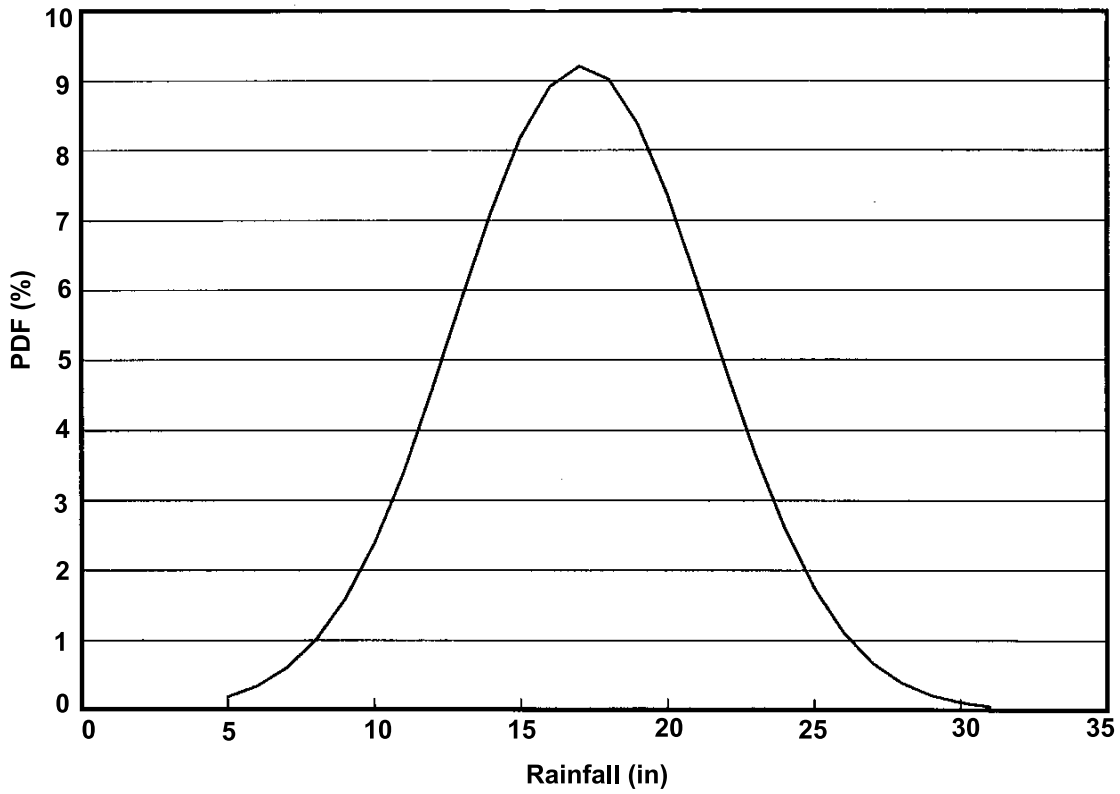

Figure I-8. Dry Season Probability Density Function.

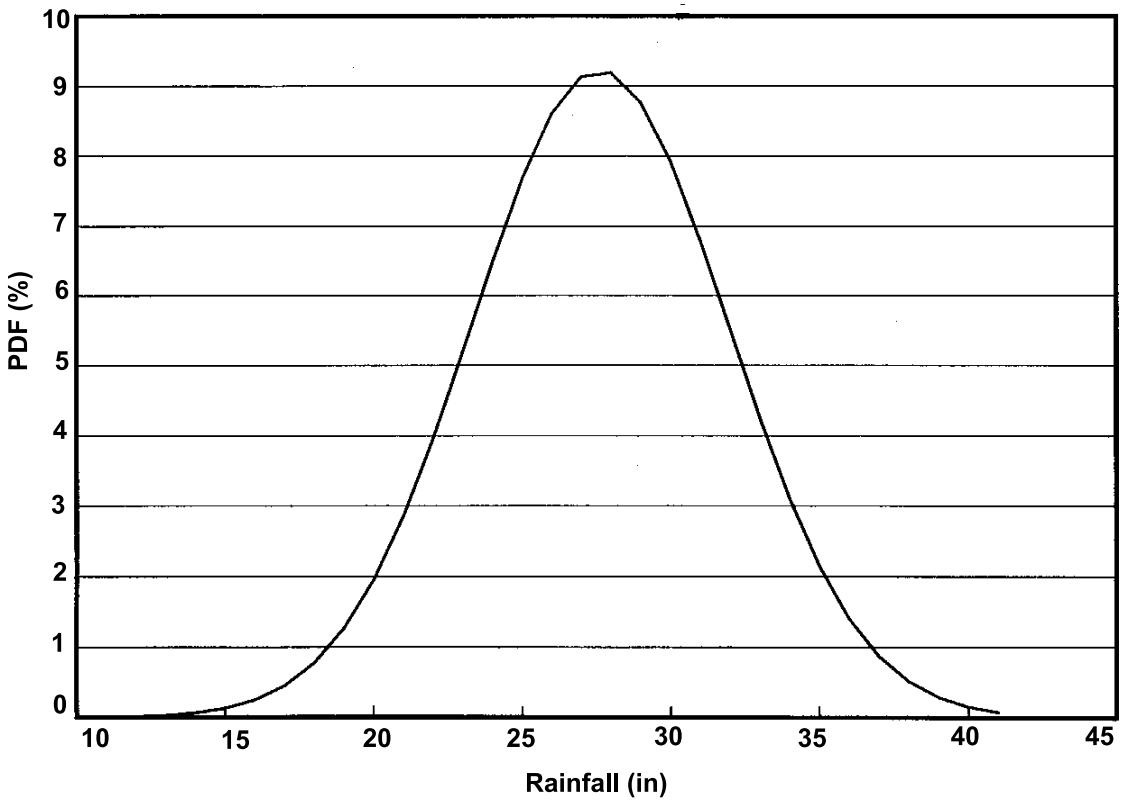

Figure I-9. Wet Season Probability Density Function.

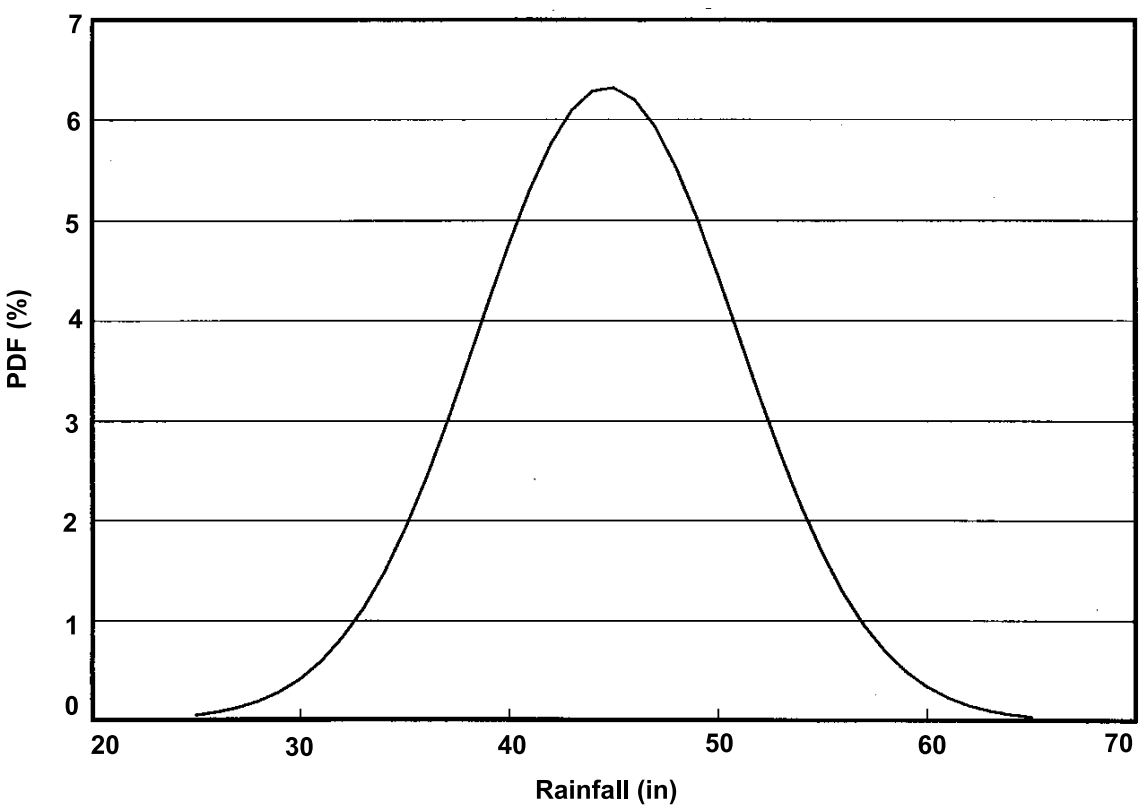

Figure I-10. Annual Probability Density Function.

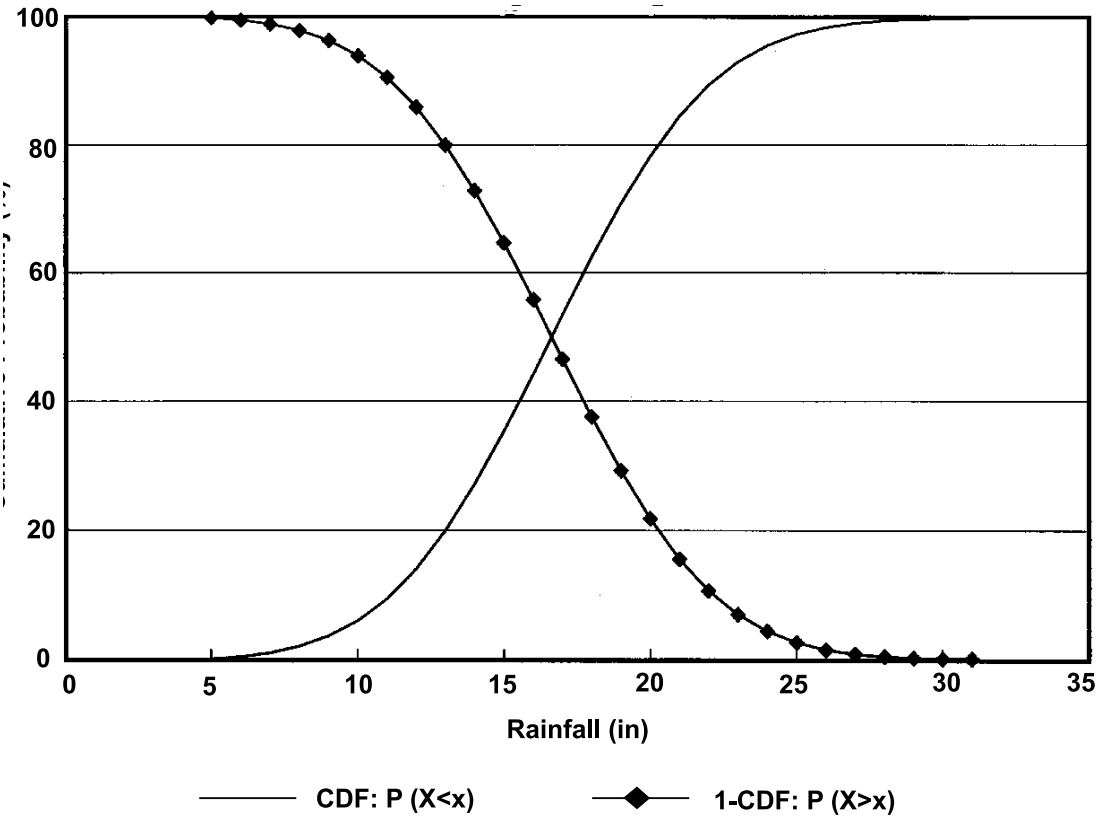

Figure I-11. Dry Season Cumulative Distribution Function.

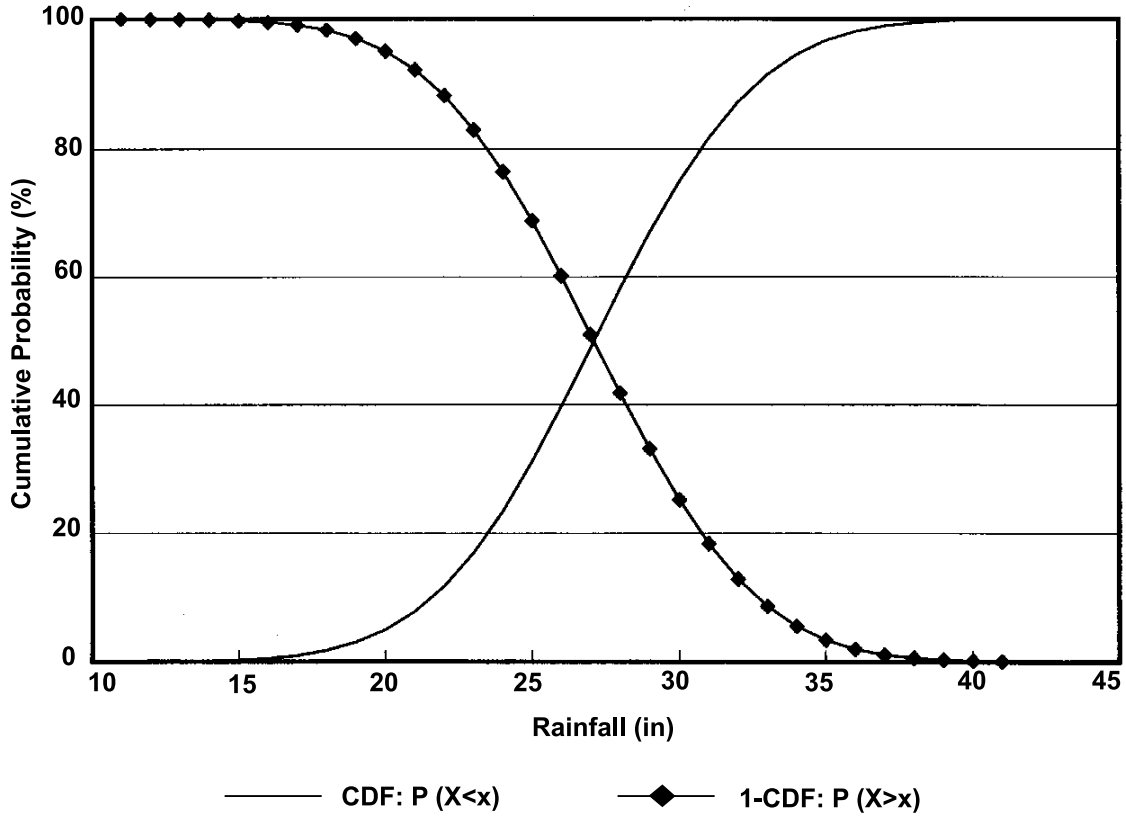

Figure I-12. Wet Season Cumulative Distribution Function.

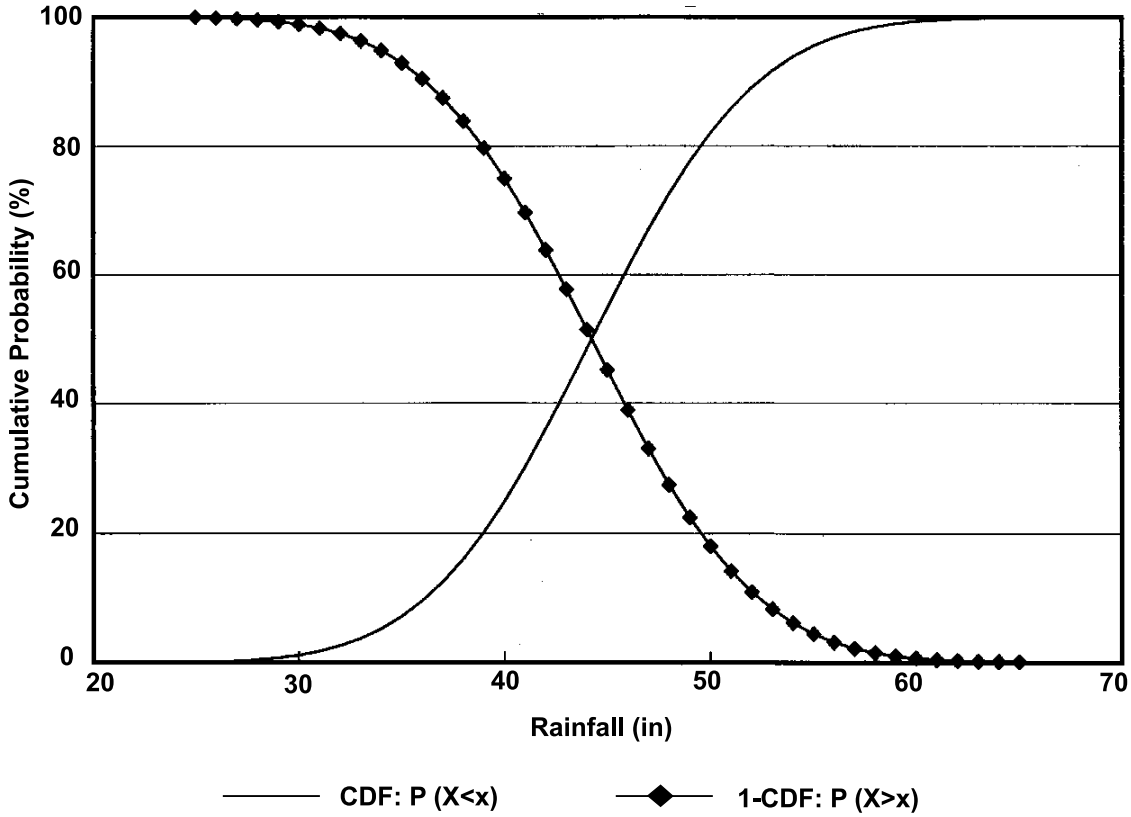

Figure I-13. Annual Cumulative Distribution Function.

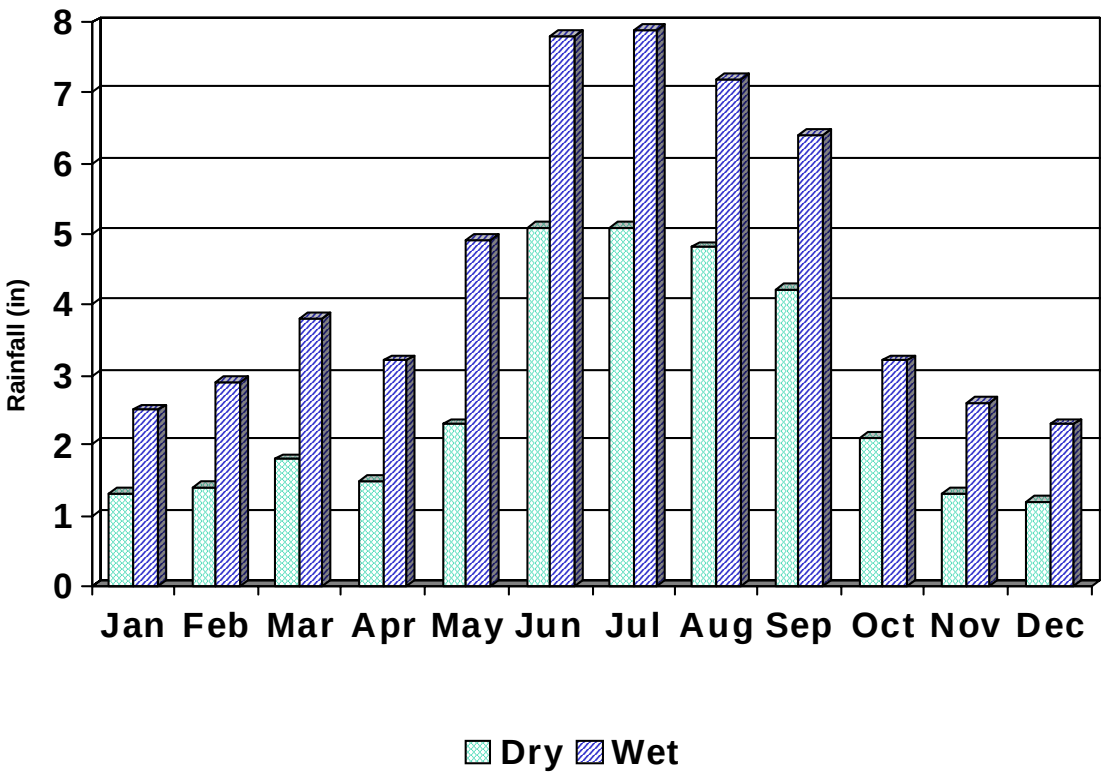

Figure I-14. Monthly Rainfall for 1-in-10 Year Conditions.